Analyses of MISSE Materials and Inclusion in the MAPTIS Database

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- Background
- Atomic oxygen scattering
- Shielding tape
- Polymeric films
- Thermal control coatings
- Thermal protection materials
- Discussion of MAPTIS database

Background

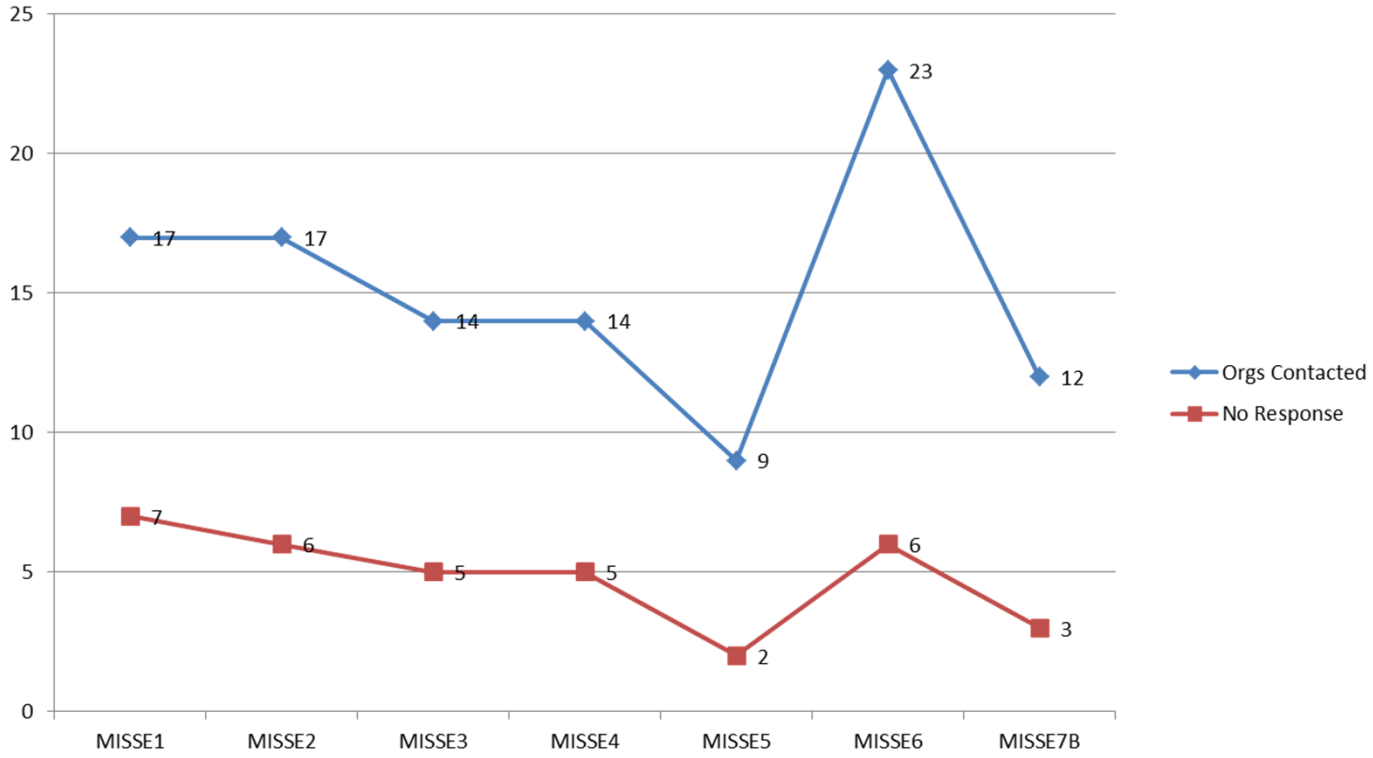
- MAPTIS = Materials and Processes Technical Information Service maptis.nasa.gov
- Started as a NHB 8060.1C (now NASA-STD-6001) database and has been growing in versatility.
- In late 2011, Dr. Gary Pippin started going through the MISSE sample lists and adding to a bibliography that Dr. Bill Kinard had started in 2008.
- A MISSE "wing" of the database was funded by the ISS Program Office to capture this knowledge into one location, to leverage the wealth of space environmental effects data into something designers and engineers could and would use.

MISSE Response

106 Organizations were contacted for MISSE information

72 Organizations provided information

34 Organizations did not respond



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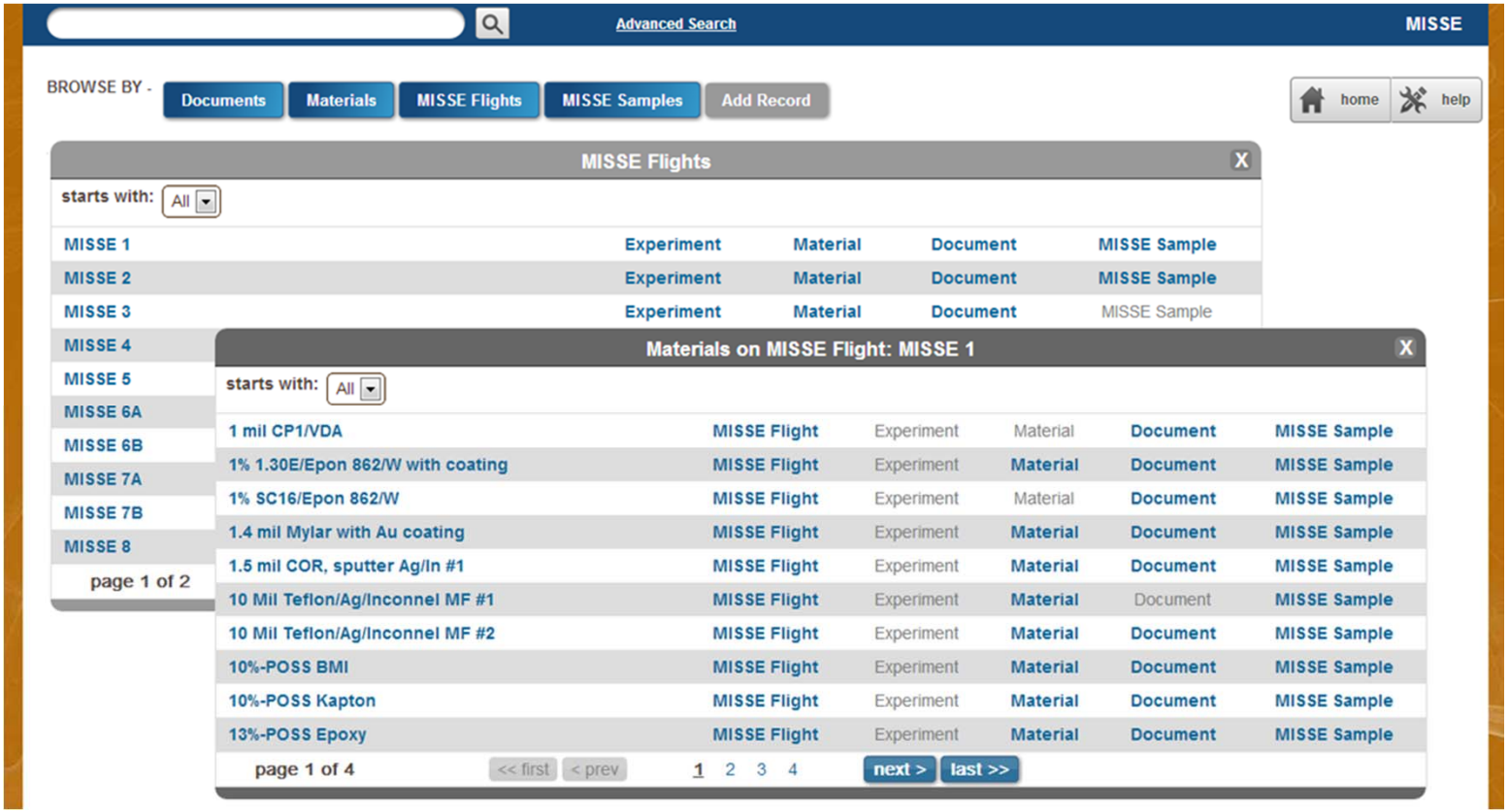
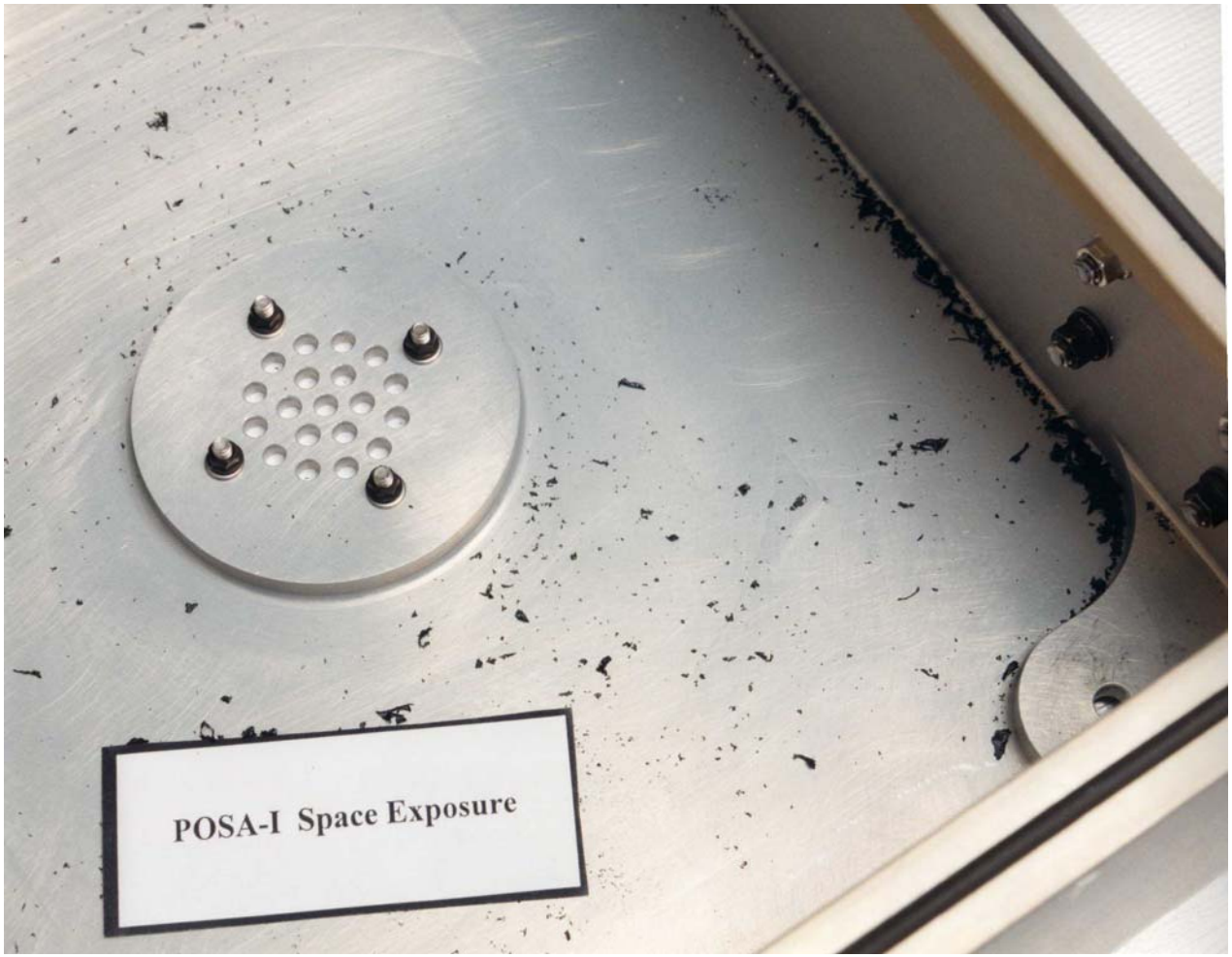
As we went through the MISSE MAPTIS database to add data, we saw samples on hand at MSFC with no linked documents. For whatever reason, the data had not been published.



Atomic Oxygen Scattering



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- AO scattering has been seen on the Mir Environmental Effects Payload (MEEP) and MISSE experiments using the Passive Experiment Carriers, mainly by silver oxide formation on silver nutplates and fasteners.
- Silver is not recommended for use in low Earth orbit because of the oxidation and particulate generation but has been used on ISS and elsewhere.
- A MSFC Atomic Oxygen Beam Facility study in 2003 of silver-plated jackscrews, barrel nuts, and nutplates indicated that AO exposure does not appear to affect the torque run-in or back-off values but duplicated the particulate generation seen on MEEP.

AO scattering must be understood for proper telescope baffle design and protecting sensitive surfaces.

References:

- Banks, B., Miller, S., de Groh, K., and Demko, R., "Scattered Atomic Oxygen Effects on Spacecraft Materials," NASA/TM—2003-212484, June 2003 and Proceedings of the 9th International Symposium on Materials in a Space Environment, Noordwijk, The Netherlands, June 16–20, 2003, ESA SP-540, September 2003.
- Banks, Bruce A., Seroka, Katelyn T., McPhate, Jason B., Miller, Sharon K., "Attenuation of Scattered Thermal Energy Atomic Oxygen", NASA/TM—2011-217028, April 2011.

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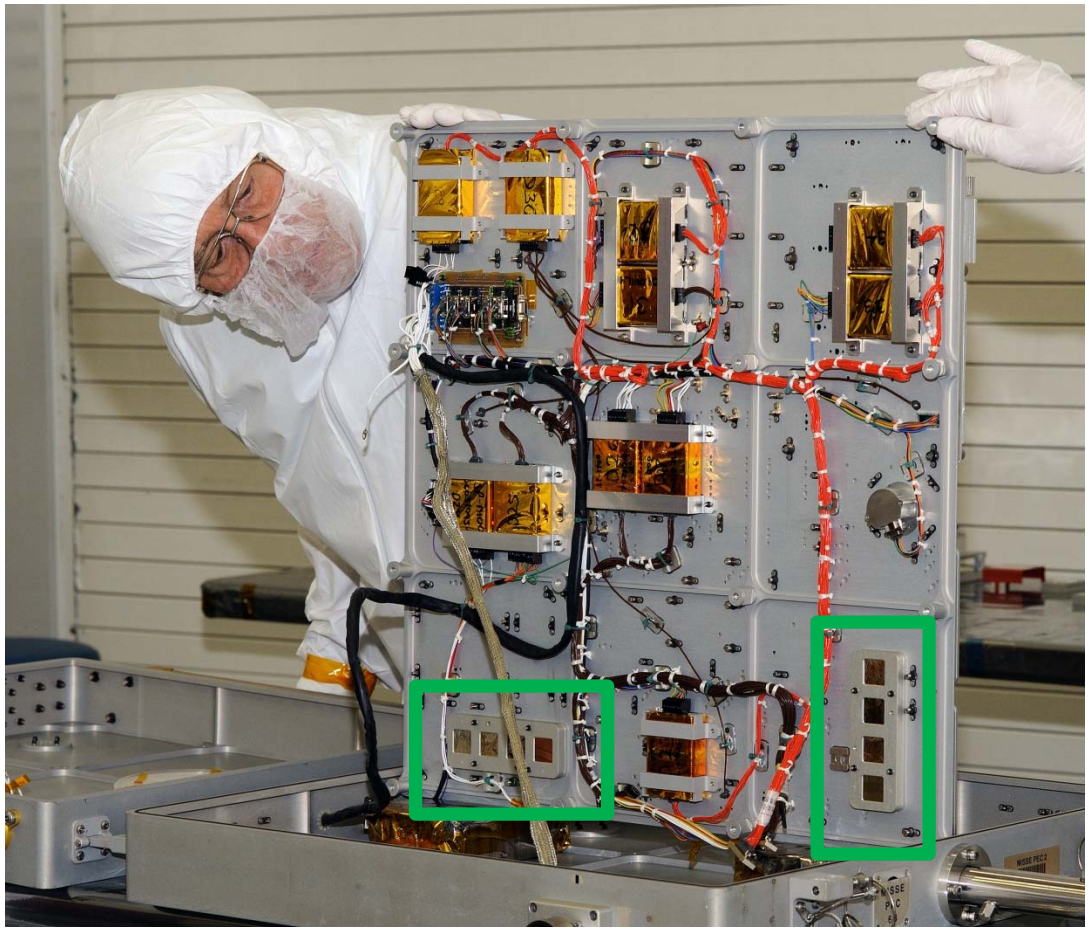
MISSE-6B contained two sample trays of candidate ballute materials and Kapton underneath the wake side baseplate.



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L to R, 7.5 µm Upilex S, 12.5 µm Upilex S, 25 µm Upilex S, Kapton. Note oxidation of silver nutplates and fasteners.

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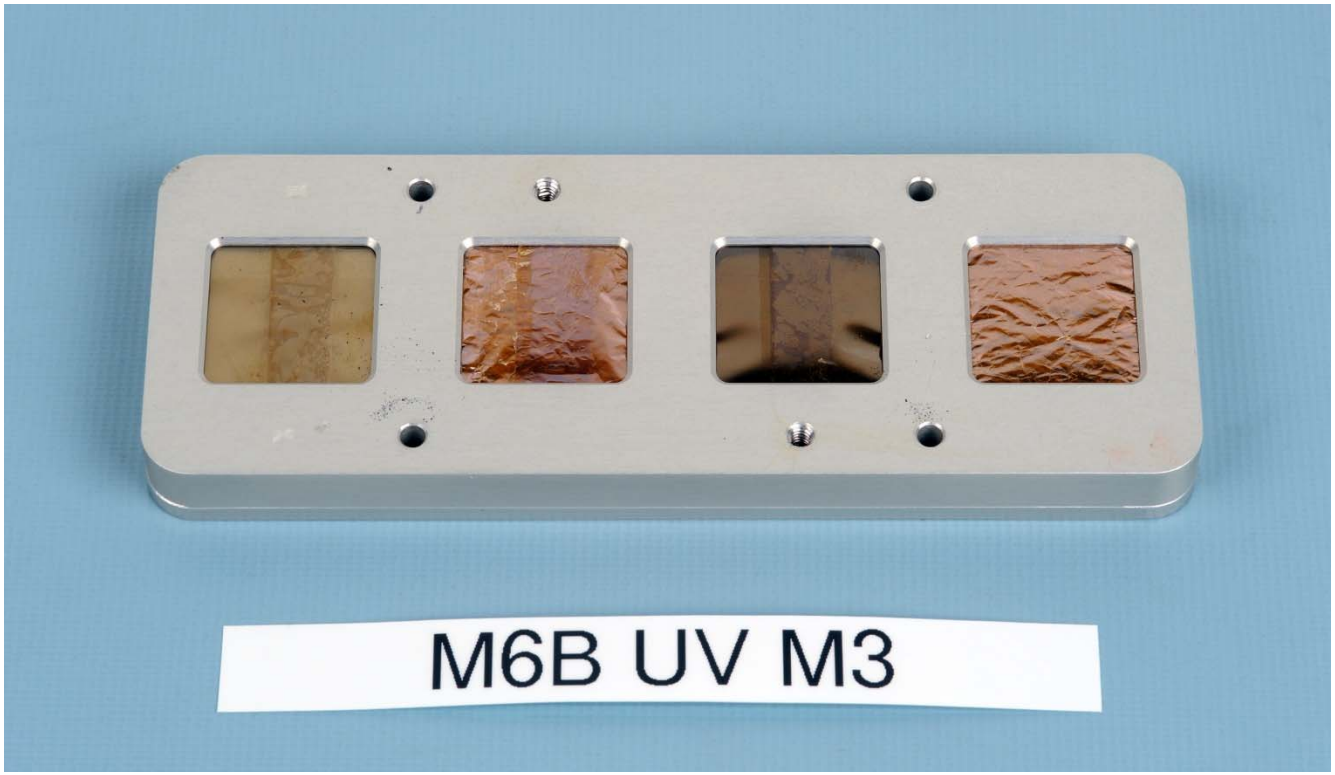


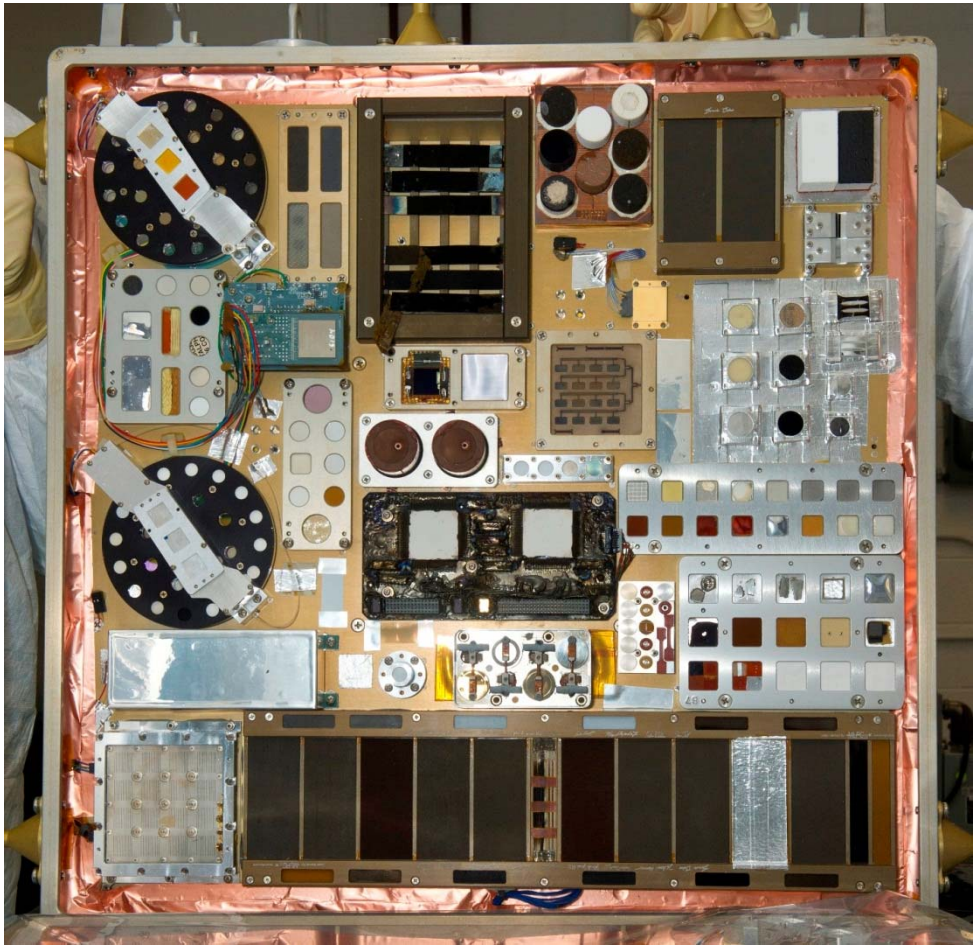
L to R, Seamed Upilex 12.5 µm, Seamed PBO 7.5 µm,
Seamed Upilex 25 µm, PBO 7.5 µm

MISSE-6 M2 and M3 Sample Trays

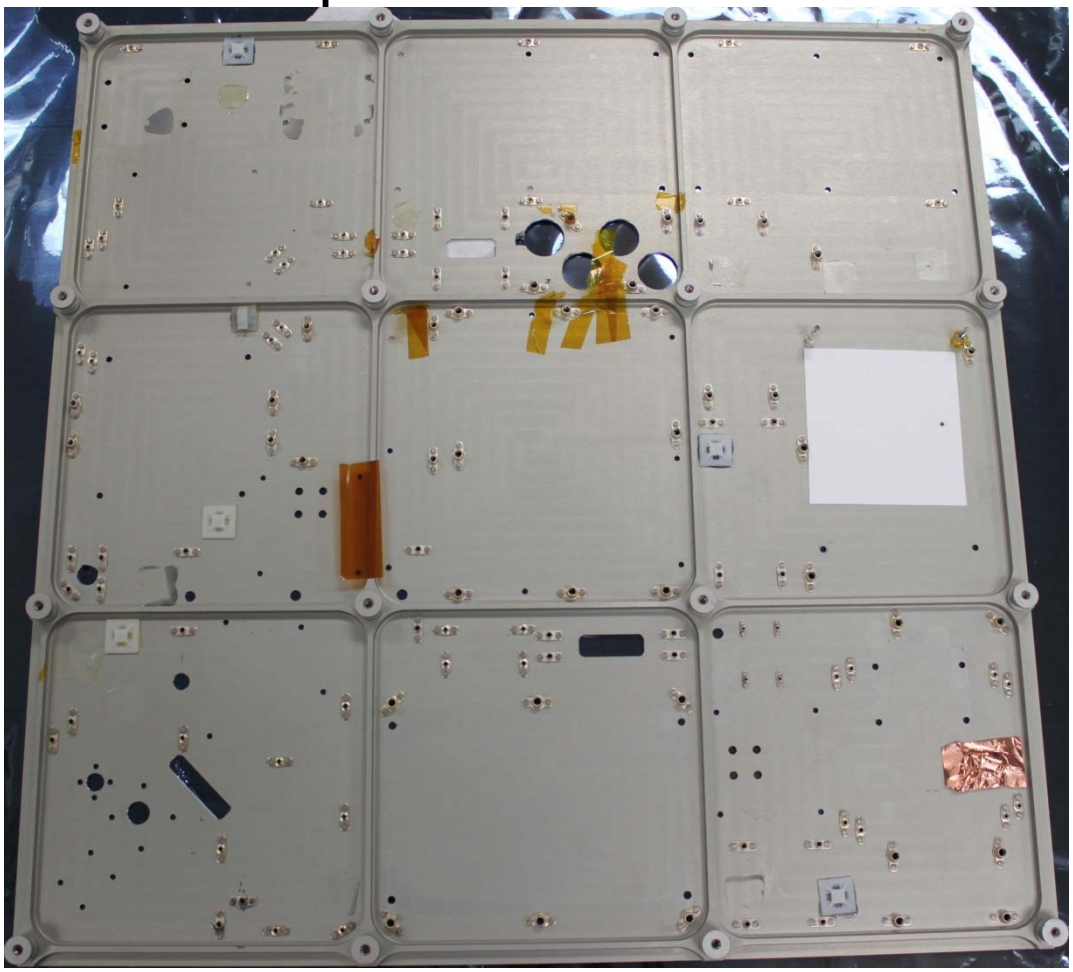
- In hindsight, it would have been better to have put this experiment underneath the ram-facing baseplate, but that was crowded with data loggers.
- No visible erosion or step edge on any sample.
- The PBO samples did not indicate any measurable mass loss.
- Using 2.81×10^{-24} and 9.22×10^{-25} cm^3/atom for Kapton HN and Upilex-S, respectively, mass loss indicates an atomic oxygen fluence underneath the baseplate equivalent to 0.8 to 2.3% that of the wake side, which was 1.21×10^{20} atoms/cm^2.

AO erosion yields from NASA TM-2006-214482, "MISSE PEACE Polymers Atomic Oxygen Erosion Results" by Kim de Groh and Bruce Banks.

By contrast, the MISSE-7B baseplate edges were sealed with copper foil shielding tape to minimize EMI.



This resulted in no silver oxidation observed underneath the wake side baseplate.



Only one area with silver oxidation observed underneath the ram side baseplate, in A8-R/B9-R area.

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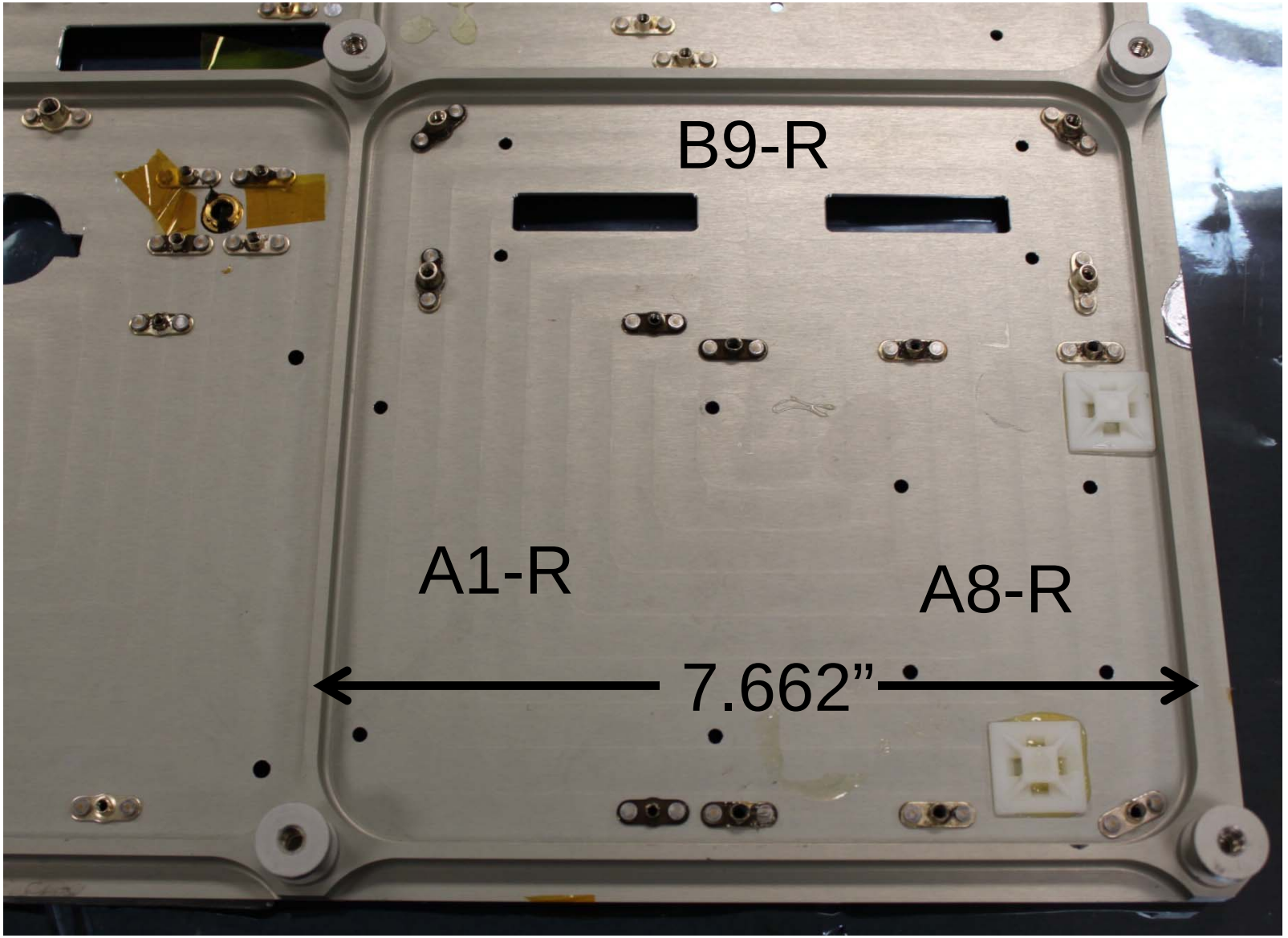

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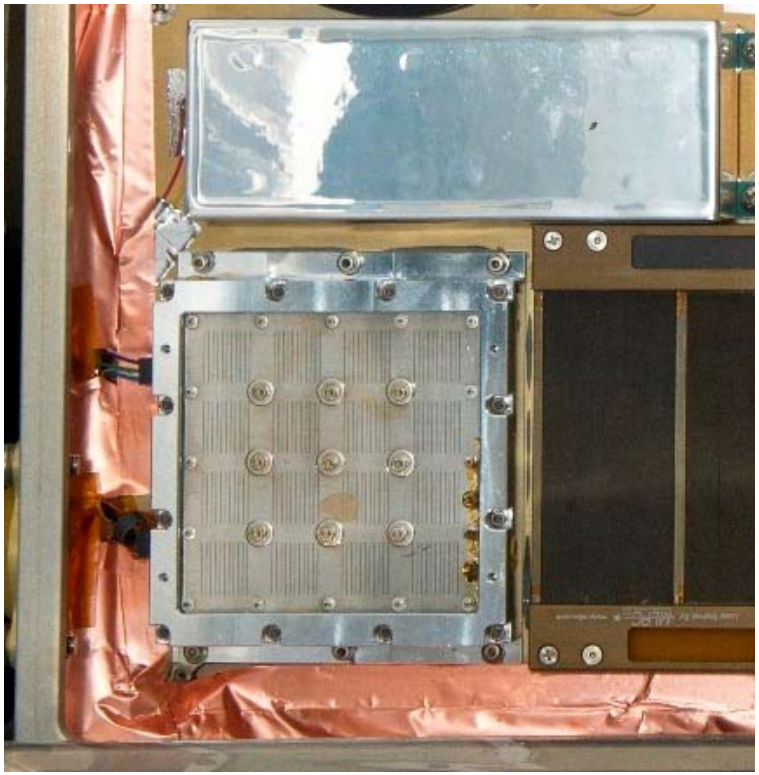
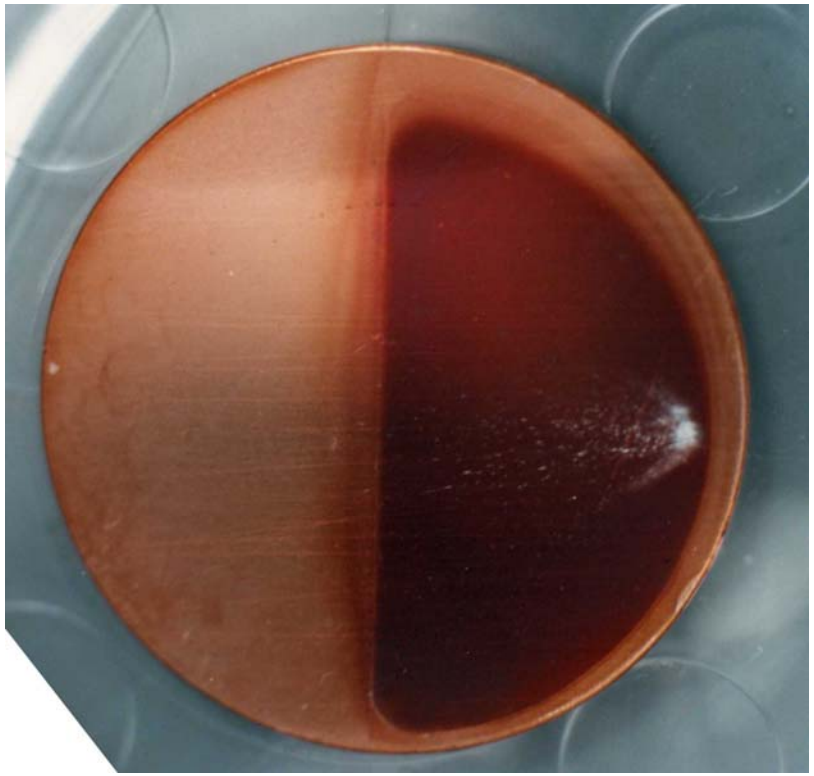




Did not see copper oxidation on shielding tape on either MISSE-7B ram or wake side. Was expecting darkening as seen on copper flown on LDEF (right, half-moon exposed)

Copper Foil Shielding Tape

Measured four samples of tape from each side and compared to pure metal samples from LDEF and EOIM-3.

Material	Solar Absorptance	Infrared Emittance
MISSE-7B Ram tape	Average $\alpha = 0.23$ Worst case $\alpha = 0.28$	$\varepsilon = 0.12$
MISSE-7B Wake tape	Average $\alpha = 0.22$	$\varepsilon = 0.12 – 0.13$
LDEF Unexposed	$\alpha = 0.35$	$\varepsilon = 0.03$
LDEF Exposed	$\alpha = 0.56$	$\varepsilon = 0.03$
EOIM-3 Pre-flight	$\alpha = 0.47$	$\varepsilon = 0.02$
EOIM-3 Post-flight	$\alpha = 0.52$	$\varepsilon = 0.03$

Polymer films

Small samples held down with anodized aluminum-lithium frames on MISSE-6A ram and wake sides.

Polymer films – MISSE-6A Ram

Unaluminized TOR film sample tore.

Germanium/Kapton film was flown with germanium exposed, maintained 5.0 x10^5 ohms/square. This film had a slightly higher solar absorptance than that flown on MISSE-7B, which had $\alpha = 0.47$ unchanged by exposure. Infrared emittance was the same.

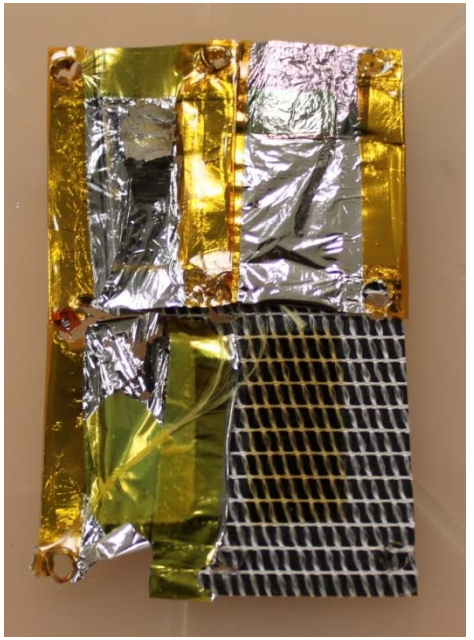
MISSE-6A Ram Side Material	Solar Absorptance		Infrared Emittance	
	Pre-flight	Post-flight	Pre-flight	Post-flight
Aluminized TOR	0.42	0.50	0.76	0.79
Silver/Teflon	0.07	0.07	0.65	0.64
Germanium/Kapton	0.51	0.52	0.85	0.85

Polymers – MISSE-6A Wake

Germanium/Kapton film was flown with reinforcing scrim exposed, which darkened.

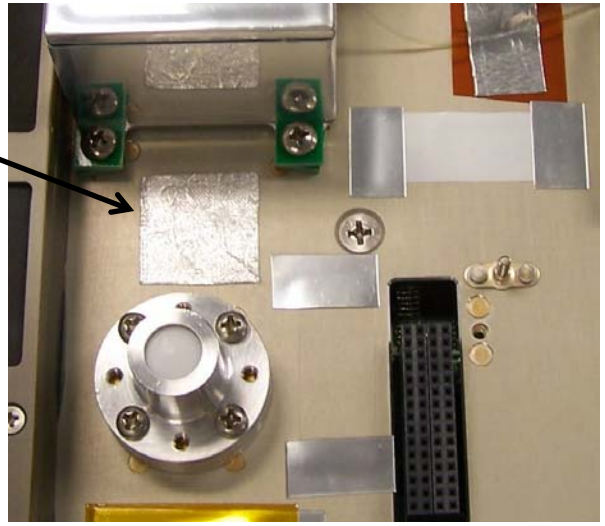
Membrane attach point sample failed.

No optical property measurements on ripstop sample.



MISSE-6A Wake Side Material	Solar Absorptance		Infrared Emittance	
	Pre-flight	Post-flight	Pre-flight	Post-flight
Grounding patch	0.58	0.56	0.06	0.16
Germanium/black Kapton – scrim side	0.81	0.87	0.90	0.89

Thermal Control Coatings



AZ-3700 low emittance coating with 3M 966 adhesive was attached directly to the MISSE-7B baseplates. Only the wake sample was immediately measured post-flight, due to AFRL sample location. AFRL returned the baseplates to MSFC to allow measurements, where we were unable to duplicate the previous emittance measurement of 0.38.

AZ-3700	Solar Absorptance	Infrared Emittance
Control	0.28	0.31
Ram	0.24	0.31
Wake	0.25	0.33

Thermal Protection Materials

Compression Pad samples are carbon phenolic, part of the Crew Exploration Vehicle and Exploration Flight Test 1 (EFT-1) heatshields. These were provided by Alan Cassell of Ames Research Center. AO erosion was evident from the velvety texture, with 1.4% mass loss for the ram-facing sample.

Compression Pad	Solar Absorptance	Infrared Emittance
Pre-flight	0.93	0.70
Ram	0.99	0.93
Wake	0.97	0.88

Ram

Wake

Thermal Protection Materials

The Hotblox samples are structural ceramic materials. Hotblox, Hotblox Lite, and Hotblox Ultralite samples were flown on MISSE-6B ram and wake and are covered in "Thermal Protection System Materials on MISSE-6", presented at the 2010 NSMMS. The MISSE-7B Hotblox samples were a follow-on to the Ultralite series and appear to be more UV-stable.

Hotblox	Solar Absorptance	Infrared Emittance
Pre-flight	0.23	0.89
Ram	0.25	0.88
Wake	0.24	0.88

Ram  Wake

More MISSE on MAPTIS

- Will make improvements based on user responses/ comments/metrics
  - Metrics including what programs are using MAPTIS, so please don't be shy if you log in and get the query screen.
- Continue to work with organizations to obtain more MISSE data
  - Will publish NASA Technical Memo "Analysis of Fluorinated Polyimides Flown on MISSE" in the next few weeks.

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For access to MAPTIS

http://maptis.nasa.gov/Request.aspx

and fill out the form.

To add MISSE data to MAPTIS – miria.finckenor@nasa.gov

or MAPTISsupport@mail.nasa.gov

Be sure to specify whether your information is unlimited access or ITAR-restricted/proprietary/ export-controlled.

Acknowledgments

- Annette Sledd, Ginger Flores, and Julie Robinson for their support
- Gary Pippin for his continued support of MISSE even after retirement
- All the MISSE investigators who have provided data
- Teresa Miller and Ben Henrie on the MAPTIS team